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TITLE: Communication methods and apparatus based on orthogonal hadamard-based sequences having selected correlation properties

Brief Summary Text (16):

In one aspect of Applicant's invention, a method of determining a scrambling code group for a received signal in a digital communication system is provided. Signals in the communication system are scrambled by respective scrambling codes; the scrambling codes are assigned to respective scrambling code groups; and identities of the scrambling code groups are encoded in the signals by respective cyclically distinct sequences of signed code words that are S-Hadamard sequences. The method includes the steps of: correlating the received signal to each of a plurality of the code words; coherently combining the correlations in accordance with cyclic shifts of each of a plurality of sequences of signs; and determining a maximal coherently combined correlation to identify the scrambling code group for the received signal.

Brief Summary Text (17):

In another aspect of Applicant's invention, a method of determining a scrambling code group for a received signal in a digital communication system, in which signals are scrambled by respective scrambling codes, the scrambling codes are assigned to respective scrambling code groups, identities of the scrambling code groups are encoded in the signals by respective cyclically distinct sequences of code words, is provided. The method includes the steps of: correlating the received signal to cyclic shifts of each of a plurality of sequences of code words that are S-Hadamard sequences; combining the correlations for each of the plurality of sequences of code words; and determining a maximal combined correlation to identify the scrambling code group for the received signal.

Detailed Description Text (16):

By correlating the received slot information with all possible code words C.sub.1 (step 506 in FIG. 5) and by coherently combining these correlation values according to sign sequences corresponding to all cyclic shifts of the sequence [m.sub.1, m.sub.2, . . . , m.sub.15, m.sub.16] (step 508 in FIG. 5), both the code word C.sub.1 and the phase of [m.sub.1, m.sub.2, . . . , m.sub.15, m.sub.16] that maximizes the combined correlation value can be determined (step 510 in FIG. 5).

Detailed Description Text (19):

This method is based on forming sequences of the members of a small set of different code words C.sub.1 that are sufficient to unambiguously identify each group of scrambling codes (step 602 in FIG. 6). It may again be assumed without loss of generality that there are 512 scrambling codes divided into thirty-two groups of sixteen codes each. By way of example only, let there be seventeen code words C.sub.1 and frames having sixteen slots each. An "alphabet" of seventeen "letters" or symbols can form many length-16 letter sequences, and many of such sequences can be proved to have reasonably good periodic autocorrelation and cross-correlation properties. Such sequence construction methods are described in "Comma Free Codes for Fast Long Code Acquisition", Doc. No. AIF/SWG2-15-6(P), IMT-2000 Study Committee, Air Interface Working Group, SWG2, which was a contribution by Texas Instruments Inc.

Detailed Description Text (20):

"Good" cross-correlation properties are such that the value of the correlation of a code word or sequence with any other code word or sequence and with any relative shifts of the code words or sequences is small. Periodic properties are important in situations in which the code word or sequence is continuously transmitted such as

the currently proposed WCDMA systems, in which the sixteen-symbol sequence of SSCs is repeated from frame to frame. Although the SSC is only one of the ten symbols sent in each slot and is in that sense not continuously transmitted, it is possible with slot synchronization established to avoid searching for the SSCs in 9/10 of the frame and thus to treat the SSCs as if they were continuous. Given any sixteen consecutive slots, therefore, the receiver can know that it has captured at least an arbitrary symbol-wise cyclic shift of the entire sixteen-symbol sequence.

Detailed Description Text (22):

The sequences of SSC code words C.sub.1 are constructed by selecting code words from the "alphabet" of seventeen code words such that the sequences are code-word-wise cyclically distinct and so that they have good mutual cross-correlation properties. For example, suppose one has two "letters" A and B, which are mutually orthogonal length-256 sequences like SSCs, and further suppose one is interested in length-8 sequences of such "letters". If one starts with the sequence AAAAABBA, then one cyclic shift of that sequence is AAAAAABB, which is distinct from the original sequence AAAAABBA. One code-word-wise non-cyclically distinct sequence is ABABABAB, and another (even more so) is AAAAAAAA. For the latter, it will be recognized that all cyclic shifts are the same, and for the former it will be recognized that some cyclic shifts are the same. Of course, it will be understood that a shift by the length of a sequence (i.e., a shift by the number of symbols) is just the original sequence again, which does not render the sequence code-word-wise cyclically non-distinct.

Detailed Description Text (27):

It will be noted that the code words C.sub.1 are not signed as in Method 1, and thus non-coherent combination of the correlations of the received slots with their respective code words is possible (step 606 in FIG. 6). For example, let C.sub.i = C(SSC.sub.i, R.sub.i) be the correlation between R.sub.i, the received information in the i-th slot, and SSC.sub.i, the i-th SSC in a hypothesized sequence of SSCs. Then, the sum of C.sub.i taken over i is the correlation between the hypothesized sequence and the received information, but since the several R.sub.i are subject to unknown and different fading or other transmission disruptions, non-coherent combining is necessary in the absence of channel estimates. In other words, the sum of the squares of the magnitudes of C.sub.i taken over i is the measure. If channel estimates a.sub.i are available, then the correlation values can be coherently combined by taking the sum over i of the products of C.sub.i and the complex conjugates of a.sub.i. With Method 1, coherent combining is necessary because the signs m.sub.i must be retained, but with Method 2, either coherent or non-coherent combining can be used.

Detailed Description Text (98):

The receiver collects the pieces and identifies the received S-Hadamard sequence in a manner as described above, e.g., by first "descrambling" the collected pieces by multiplying them by all of the appropriate cyclic shifts of the special sequence used to form the high-order S-Hadamard sequence (see step 702 in FIG. 7). As one example, the special sequence can be a length-2<sup>sup</sup>.12 orthogonal gold code. Then, the receiver correlates, either by brute force or FWT, the collected pieces in the order indicated by the descrambling against the members of the set of high-order S-Hadamard sequences to identify the member received (see step 704 in FIG. 7). As noted above, the receiver can be configured as any of FIGS. 9A, 9B, 9C.

CLAIMS:

1. A method of determining a scrambling code group for a received signal in a digital communication system, in which signals are scrambled by respective scrambling codes, the scrambling codes are assigned to respective scrambling code groups, identities of the scrambling code groups are encoded in the signals by respective code-word-wise cyclically distinct sequences of signed code words, the method comprising the steps of: correlating the received signal to each of a plurality of the code words, wherein the code words are S-Hadamard sequences; coherently combining the correlations in accordance with cyclic shifts of each of a plurality of sequences of signs; and determining a maximal coherently combined correlation to identify the scrambling code group for the received signal.

3. A method of determining a scrambling code group for a received signal in a digital communication system, in which signals are scrambled by respective scrambling codes, the scrambling codes are assigned to respective scrambling code groups, identities of the scrambling code groups are encoded in the signals by respective code-word-wise cyclically distinct sequences of code words, the method comprising the steps of: correlating the received signal to cyclic shifts of each of a plurality of sequences of code words, wherein the code words are S-Hadamard sequences; combining the correlations for each of the plurality of sequences of code words; and determining a maximal combined correlation to identify the scrambling code group for the received signal.